Raising Ranchers in New Mexico
A Guide

by

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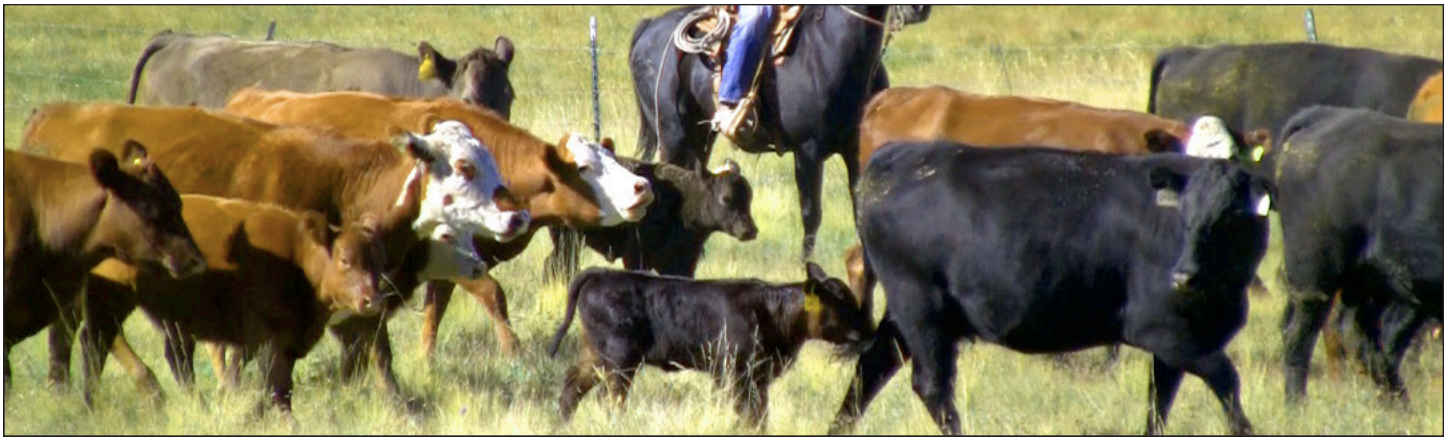

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Preface

The median age for ranchers and farmers in New Mexico is nearly 60 according to the 2017 USDA Census which is an increase from the 2012 USDA Census. Additionally, there was a decline in producers under the age of 34 in that same time period. This troubling trend indicates that entering into a farming or ranching business is becoming increasingly more challenging even though the vast majority of land in the state is suitable for livestock and farm production. It is also worth noting that agriculture is second only to the energy industry as an economic engine for New Mexico. The two make up nearly 50 percent of the state's economy.

Where will future ranchers and farmers come from?

To begin to remedy this problem the Cattlegrowers' Foundation Inc. (CFI) joined the New Mexico State University Cooperative Extension service to secure a grant from the USDA National Institute of Food & Agriculture (NIFA) entitled Raising Ranchers. The purpose of the project was to begin educating young ranchers on livestock production.

Unfortunately, the COVID shut down seriously hampered efforts for hands-on teaching and learning. New Mexico was among the last of the states to reopen after the shutdown.

One of the major projects, however, was the purchase of a chute and portable corral system that are available to beginning ranchers at a nominal fee to cover maintenance. The goal is to help beginning ranchers administer their annual cattle management practices without spending significant amounts on facilities. These are available by contacting:

Extension Animal Sciences and Natural Resources
Knox Hall, Room 232
P.O. Box 30003 MSC 3AE
Las Cruces, NM 88003
Phone: (575) 646-3326
Fax: (575) 646-3164

This publication is another major success of the project.

Hard copies of this book are available at no cost from your local county extension office, the Cattlegrowers Foundation Inc., cattlegrowersfoundationinc@gmail.com and https://nmdeptag.nmsu.edu/media/pdf/2020-NM-Ag-Statistics.pdf

Getting Started

If you are reading this, it likely means you are considering starting a ranch in New Mexico. Ranching can be one of the most rewarding experiences you will undertake but will certainly be full of challenges. The information provided in this book is not intended to be all encompassing, but rather provide considerations for getting started with the assumption that the reader is also juggling other life endeavors. Most that are starting in the ranching business are starting as a side business and often have numerous other life commitments as well as another source of income. As such, the content is intended to discuss starting a ranch with the perspective that time, economic efficiency, sustainability, and life quality must all be balanced. The content is not all encompassing but is intended to be a starting point for considerations before starting your ranching enterprise.

Brand Inspection

In New Mexico it is mandated by law that you put a permanent "fire brand" on your cattle prior to movement from your ranch. You must first register your brand with the New Mexico Livestock Board located at 2105 Osuna Rd, NE Building South, Albuquerque, NM 87113. The recording fee is $100, and the brand must be renewed according to New Mexico Livestock Board regulations. The brand is your property as long as it is kept in good standing. You will be able to sell or transfer your brand if you wish.

If cattle are to be moved from your ranch and across county lines, you must have your animals inspected by a New Mexico Livestock Board Brand Inspector. If you are hauling them to a licensed New Mexico Livestock Auction, you can also call the Auction to obtain a travel permit. If you are going anywhere other than a licensed New Mexico Livestock Auction, you will need to have your animals inspected. The Brand Inspector will require that your brand on the animal is "healed and peeled" which typically takes 3 to 4 weeks after the brand is placed on the animal.

If you wish to import cattle into New Mexico, you must comply with all interstate transport regulations and New Mexico Livestock Board regulations. Prior to moving any animal into the state, contact a veterinarian or livestock inspector in the state of origin. The veterinarian and/or livestock inspector can help determine the appropriate transportation requirements to get the animal into New Mexico. Once the animals arrive, you are required to have a New Mexico Brand Inspector provide an entry inspection. For any questions, contact the New Mexico Livestock Board.

Premises Identification Number

Though not required, you should consider obtaining a premises identification number from the United States Department of Agriculture. If you plan to purchase USDA official identification tags, you will need your premises identification number. You may contact the New Mexico Livestock Board to get more information on premises identification in New Mexico.

Veterinarian-Client-Patient Relationship

A Veterinarian-Client-Patient Relationship or VCPR is an established relationship in which a veterinarian knows a client, the client's operation, and has visited the operation in person. The veterinarian must have knowledge of the client and the client's operation. Your responsibility in the VCPR is to allow your veterinarian to make health decisions regarding your herd and follow the instructions provided by your veterinarian. Your veterinarian is responsible for making health judgments, accepting responsibility for providing your animals with medical care, providing oversight of treatment, and providing emergency care as needed. It is important to establish a VCPR early so you can seek advice from your veterinarian for care of sick animals, vaccination recommendations, dystocia, or other problems that may arise.

Miscellaneous

Each county in New Mexico may have varying tax rates, zoning regulations, or other regulatory considerations. Be sure to check with local offices for any tax obligations or regulations you must follow.

Lease Considerations

For most starting in a ranching enterprise, a grazing lease is the most affordable option to grow a livestock operation without the significant capital investment required to purchase large tracts of land. Leased land also avoids paying interest and a high down payment reserving more startup capital for feed, livestock, or equipment. However, there are trade-offs and a relative lack of security for long-term production in most lease agreements. Thus, it is critical to fully evaluate the conditions of a grazing lease.

The first step in any leased pasture arrangement is to generate a written agreement to be signed by both lessor and lessee. Written agreements are essentially contracts that can protect both parties and relationships because all conditions are described prior to any cattle grazing the leased ground. These written agreements also help both parties critically evaluate all the details and make sure the details are well thought-out. Should the unexpected happen, a written lease will also provide protection for both parties involved. For example, if there is a death or sale of the property, does the lease continue? If it does continue, for how long? It is imperative that every detail and every promise involved in a lease agreement be included in the writing.

Another consideration is agreeing on when and how the lease ends. This sounds simple enough, but consider a drought situation and well over 50% of the forage is gone. Will the lessor allow the lessee to remain on a portion of the pasture and feed livestock? Will the lease be terminated when certain percent use has been met? What about in the event of wildfire? Will the lessee be reimbursed for any loss grazing or does the lessee bear all risk? It is very important to discuss these conditions prior to turning any livestock out on the pasture. Do not forget to discuss who maintains things like fences, pumps, water tanks, etc.

Pasture lease rates may be set on a per-acre or per-head basis which is most common. If using this fixed-cost approach, it is very important to negotiate limits on stocking rates. You as the lessee should evaluate the stocking rates and cost to make sure you can generate enough of a profit to support your new operation. Don't forget that you will still need to supplement (discussed later) and if the forage runs out, your cost remains the same even though you will have to make new arrangements to feed. In some cases, lessors will charge a fixed charge per pound of gain which is most often used in stocker operations. This shifts some of the enterprise risk to the lessor, but can result in larger profits for them in good years. Either way, clearly determine the appropriate stocking rate before the forage is becoming limiting. You can seek help with your local Cooperative Extension Service for stocking recommendations.

It is also worth noting that in New Mexico, many ranches are sold with a relatively small amount of deeded or private ground that is tied to leases administered by state or federal agencies. Prior to purchasing a ranch with these types of arrangements, you should discuss the lease agreements with the grazing managers from the state or federal agency. Be aware that historical stocking rates are subject to change at any time based on forage availability, endangered species, or other benchmarks. Additionally, grazing on state and federal lands may require grazing or enterprise planning along with other production practices. Ultimately, the decision to increase or decrease stocking rates, rest pastures, etc. rests with the grazing managers. Be sure to completely understand all aspects of these arrangement prior to purchasing a ranch under these conditions.

Building a Herd

The first step to building a successful cow herd in New Mexico is to begin with the end in mind. What will be your business goals and how do you plan to market? Are you going to raise spring-born calves to sell in the fall? Are you going to raise niche' beef to sell locally or try to raise seedstock for a particular breed? There are numerous sectors that new ranches can try to target, but it is important remain realistic in your approach and weigh the economic potential for each of these options.

For the commercial cow herd, one of the most important things to consider is that New Mexico rangelands exist in harsh environments. The forage availability and stocking rates are much lower than observed in other parts of the United States. As such, cattle in this region must thrive on limited forage and travel rough terrain over long distances to obtain enough feed and water to produce. Cattle that are not adapted to this region will not reproduce at best and at worse, will likely suffer severe health problems or death. When getting started, the best approach is to identify successful cattle operations in the region and consider sourcing your female base from these operations. If they are longstanding and successful operations, then their herd is likely well-adapted to the environment. Bringing in cattle from outside the region poses a significant risk to productivity.

Raising Replacements

Puberty and when it occurs:

Puberty is the age at which a female can support pregnancy without deleterious effects. In most beef operations, calves are weaned at 6 to 8 months of age. The calves are then expected to reach puberty and be able breed at approximately 1 year of age (or just over) and calve for the first time at approximately 2 years of age. For example, a heifer calf is born in February 2022, weaned in October 2022, bred May 1st, 2023, and calves February 7th, 2024 (heifer is approximately 2 years old). In general, heifers that calve at 2 years of age have greater lifetime productivity and greater economic return over their lifetime. Heifers with Brahman or Bos indicus influence can have delayed puberty and often will not breed until they are 2 years old and calve at 3 years old. For example, in Brazil, Nelore cattle calve for the first time at 3 to 4 years of age. Thus, there are difference across breeds and within breeds on age of puberty.

Physiology of puberty:

The main limitation of puberty (i.e. what holds puberty back) is the brain or more specifically the hypothalamus. The hypothalamus is the general; when the heifer is ready, the hypothalamus tells the pituitary to release the hormones luteinizing hormone (LH) and follicle stimulating hormone (FSH). LH and FSH are foot soldiers that travel through the blood and tell the ovary to develop and release the egg (oocyte). The maturation of the hypothalamus to tell the ovary to develop and release an egg is the hallmark of puberty.

Management for puberty:

Our best estimate or target for puberty in beef cattle is body weight. Thus, most management considerations relating to developing puberty in heifers is nutrition. Traditionally, it was thought that heifers needed to be 65% of their mature body weight in order to reach puberty.

Example: a heifer is weaned at 8 months of age and weighs 550 pounds. When she is mature, she will weight approximately 1200 pounds. So, 1200 pounds x 0.65 = 780 pounds. That means she needs to gain 780 pounds – 550 pounds = 230 pounds from weaning to breeding.

Recent data suggests that 55% of the mature body weight is sufficient to initiate puberty. Why this matters:

Example (same heifer as above): 1200 pounds x 0.55 = 660 pounds. That means she needs to gain 660 pounds – 550 pounds = 110 pounds from weaning to breeding.

So, if you wean October 15th and your target breed day is May 1st, you must calculate the number of days between October 15th and May 1st. A quick calculation and you will find it is 199 days until breeding date.

Hint: a good website to help with calculations is https://www.timeanddate.com/date/duration.html

At 65% that means your heifer would need to gain 230 pounds/199 days = 1.15 pounds per day.

At 55% that means your heifer would need to gain 110 pounds/199 days = 0.55 pounds per day.

Which weight do you target? There is still some debate on this, but a good target weight is 60% of mature body weight or gaining about 0.85 pounds/day for a heifer that is weaned at 550 pounds, has about 200 days from weaning until breeding, and will have a mature weight of 1200 pounds.

There have been several strategies proposed to reduce age at puberty or decrease cost to get heifers to puberty. One of those is flushing. The idea is to grow heifers very slowly until 45 days before breeding then increase the rate of gain in the last 45 days. Certainly, some benefits have been observed doing this, but in general, getting your heifer to 60% of her mature weight is critical.

Important note: Bos indicus cattle are different. Age and other unknown factors also influence age at puberty.

Management traps:

Be cautious of developing heifers in a feedlot and then turning them out to pasture for breeding. If you purchase heifers, be aware of how they were raised. Problems can arise when heifers are weaned, placed in a lot, fed a high level of nutrition, and then turned out to pasture for breeding. The heifers will likely travel more and eat less which makes the hypothalamus think the heifer is in a poor nutritional state. Reproduction is a luxury and just as the hypothalamus can initiate puberty, the hypothalamus can shut down reproduction. In real world settings, heifers raised in a lot, sold, and put out to pasture for breeding can have substantially reduced pregnancy rates.

Even though smaller (than the national average) and more efficient cattle are necessary in New Mexico, it is still important to produce a marketable calf. If selling weaned calves either at a sale barn or to a buyer, the price is set based on feeder cattle grades. USDA frame scores are predictions of live weights at which steers and heifers are expected to produce carcasses with approximately 0.50 inch of finish (external fat) and grade choice. Table 2 shows 3 frame scores and how they relate to predicted slaughter weight. Generally, cattle with larger frames will require more feed and time to finish, but will have greater average daily gains and heavier carcasses. Small-framed cattle often finish faster but risk being over finished, resulting in carcass discounts from less desirable yield grades. Feed prices and demand dictate market prices, but in most years, upper-medium and perhaps lower-large framed cattle bring the greatest price. Small-framed cattle typically produce lower yielding carcasses and are often substantially discounted at all segments of the beef chain. The extreme environment in New Mexico makes it necessary to utilize small to moderate frame scores in the cow herd. Thus, if producers are being discounted due to smaller-framed cattle, larger-framed terminal cross sires can be utilized to improve frame score.

USDA Frame Score	Steer Finish Weight	Heifer Finish Weight
Large	1250 lbs +	1150 lbs +
Medium	1100-1249 lbs	1000-1149 lbs
Small	Under 1100 lbs	Under 1000 lbs

Table 1. Frame score (left column) predicts final harvest weight for steers (middle) and heifers (right column).

Age must be considered when assigning frame size. When feeder cattle mature, the head appears to increase in size relative to the body. Additionally, the ears look shorter or smaller relative to head size while the muzzle is proportionately wider. Other age indicators include; the head becomes longer in relation to head width, feet are larger relative to size of bone, and tail length increases with a longer and more course switch. Breed must also be considered. For example, largest size in a smaller breed and the smallest size animal from a large-framed breed both might both be considered medium frame score animals.

Large (often designated "L" on market reports) Feeder calves that are thrifty, have large frames, and are tall and long bodied for their age. Steers will likely be 1250 pounds or greater when having 0.50 inch external fat at the twelfth rib and grading USDA Choice at harvest. Heifers will be 1150 pounds or greater.

Medium (often designated "M" on market reports) Feeder calves that are thrifty, have slightly large frames, and are slightly tall and slightly long bodied for their age. Steers will likely be 1100-1249 pounds when having 0.50 inch external fat at the twelfth rib and grading USDA Choice at harvest. Heifers will be 1000-1150 pounds.

Small (often designated "S" on market reports) Feeder calves that are thrifty, have small frames, and are shorter bodied and not as tall as Medium Frame cattle. Steers will likely be less than 1100 pounds or when having 0.50 inch external fat at the twelfth rib and grading USDA Choice at harvest. Heifers will be less than 1000 pounds.

Muscle Thickness Score

Muscle thickness is scored from 1 to 4 based on the muscle composition of the calf relative to development of the skeletal system. It is important to note that the 4 grades are based on descriptions of thickness and fullness of the muscle at certain points on the animal, and, since fat can influence the appearance, the descriptions are based on animals that have a slightly thin covering of fat. Considerations of finish are discussed below.

No. 1 (designated as 1 on market reports). Typically predominate beef breeds that are thrifty and moderately thick throughout (remember, extremely thick double muscled cattle are considered unthrifty). Points of thickness and fullness are noticeable in the forearm and gaskin with a rounded appearance through the back and loin. Feeder cattle in this grade also moderate width between front legs and back legs. Cattle can be eligible for this grade even if they carry varying degrees of fat.

No. 2 (designated as 2 on market reports). Normally these cattle are beef breeding but can have slight dairy influence. They are thrifty and slightly thick throughout. Though less than No. 1, they are still slightly thick through the forearm and gaskin, with a rounded appearance through the back and loin. They are slightly wide between the legs, both front and rear. From behind, cattle in this grade have a square appearance over the tail head and down to the legs and feet.

No. 3 (designated as 3 on market reports). Generally, these cattle are thinly muscled throughout. They are thrifty with thin muscle through the gaskin and forearm. The back and loin have a sunken appearance and are narrow between front and rear legs. When viewed from behind, cattle in this grade have a triangular appearance with the widest part over the tail head and narrowing to legs and feet.

No. 4 (designated as 4 on market reports). These animals are thrifty but possess less muscling than animals in grade 3.

Flesh

Feeder cattle grades are assigned to animals with a thin fat covering, but grades can be assigned to animals with varying fat cover. Flesh or fat cover alters the animal's appearance and impacts price of feeder cattle. Probably the best estimate of flesh is the numerical body condition score system used in cows but applied to feeder cattle. Very thin to thin animals would be considered 1 to 3 while cattle in moderate or average flesh are scored 4 to 6. Fleshy animals are 7 to 9 and have a pronounced fat cover. Poor pasture conditions can lead to calves that are considered "poor" or "thin," and depending on market situations, can be discounted at sale. "Light medium" or slightly fleshly calves are healthy, strong, with little fat covering. These are ideal stocker calves and are often near the upper end of the market if appropriately managed. "Fleshy" calves have excess fat covering for their age and are almost always discounted when sold. If producers are weaning calves for extended periods, care should be used to not overfeed calves to the point of excessive fat deposition.

As you can see, muscle and bone structure are very important to price you receive for your calves. Though it is important to develop a moderately-sized cow herd, consider using bulls that will compliment your cow herd through improved muscle and frame scores. Be careful to maintain moderation in your herd when keeping replacement females.

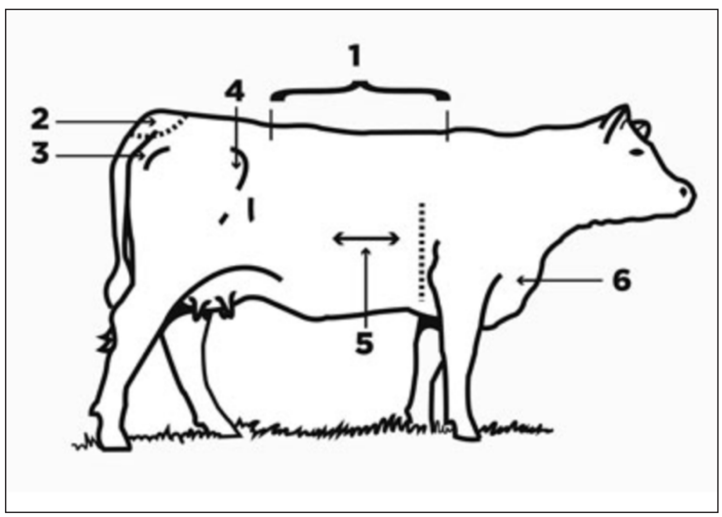


Figure 1. Key points for body condition scoring. 1. back, 2. tail head, 3. pins, 4. hooks, 5. ribs, 6. brisket

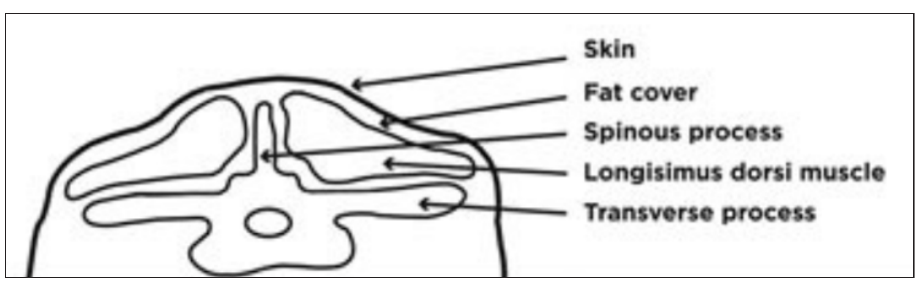


Figure 2. Cross-sectional view of a cow's back.

Above illustrations originally published in Managing and Feeding Beef Cows Using Body Condition Scores, Circular 575, Revised by Marcy Ward, Author: Extension Livestock Specialist, Department of Extension Animal Sciences and Natural Resources, New Mexico State University, found here https://pubs.nmsu.edu/_circulars/CR575/

Building a Herd Health Program

Health issues can be one of the largest challenges facing a ranching enterprise. Fortunately, if a good health program is followed, the risk of financially devastating disease problems can be avoided. The first step as outlined earlier, is to make sure you establish and maintain a good working relationship with your veterinarian. It should be noted that your veterinarian's recommendations should be followed and the following information is merely a general guideline to provide a starting point for considerations.

A cow's immune system is comprised of two main branches called the innate and the adaptive. The innate system is relatively non-specific and is the first line of defense against pathogens. Some examples of the innate immune system include physical barriers like skin and mucosal linings of the respiratory tract. Generally speaking, managing the innate system mainly involves keeping animals in good condition with feed, water, and mineral supplementation. If an animal is in overall good health, the innate system should be functioning properly.

The adaptive system involves several immune cell types including B- and T-lymphocytes. This system is highly specialized to target individual pathogens. The goal of a livestock producers it to build a robust and highly responsive adaptive immune system in their herd. The best tool we have to develop a strong adaptive immune system is a vaccination program. However, simply injecting a vaccine does not guarantee immunization. Proper vaccination procedures and low stress animal handling must be used in order to get the most effective response from the vaccines we purchase.

Again, your veterinarian can recommend the vaccinations you should consider using in your area, but the vaccinations will likely fall into a few classifications. Modified live vaccines (MLVs) are attenuated microorganisms that replicate in the animal but without (or with minimal) clinical signs typically seen with natural exposure. These vaccines must be stored, mixed, and administered according to label in order to be effective. Mishandling MLVs will kill the vaccine virus, thereby failing to immunize the animal. Killed or inactivated vaccine consists of virus particles, bacteria, or other pathogens that have been grown in culture then killed and mixed with adjuvant for injection. Chemically altered vaccines contain modified live organisms that have been grown in a media containing adjusted levels of certain chemicals which cause a mutation to the microorganism. The mutation then causes the microorganism to die at body temperature when injected, for example. Each of these vaccine types have positives and negatives as well as varying safety levels depending on class of cattle. Read the labels carefully and consult with your veterinarian for recommendations.

Bovine respiratory disease remains the largest challenge facing the beef industry, resulting in billions of dollars of economic losses every year. Starting calves on a good vaccination program is the best preventative tool we have available to us and it is imperative the vaccination program starts early in the calf's life. Prevalent viral agents include infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), bovine respiratory syncytial virus (BRSV), and parainfluenza type 3 (PI3). Bacteria implicated in BRD infection include *Mannheimia haemolytica*, *Pasteurella multocida*, *Haemophilus somnus*, and *mycoplasma bovis*. As such, most vaccine programs build around immunizing against some or most of these pathogens.

A general recommendation for calves is the following:

2–3 months

- Clostridial 7-way (or 8-way)
- Parenteral MLV IBR, BVD, PI3, BRSV or Intranasal IBR, PI3, BRSV
- * A killed vaccine for IBR, BVD, PI3, BRSV is less desirable and label guidelines for booster should be followed.

Weaning

- Clostridial 7-way (or 8-way)
- Parenteral MLV IBR, BVD, PI3, BRSV
- Mannheimia/Pasteurella
- Treat for internal and external parasites

In some cases and for some programs, you may consider another booster for the respiratory viruses as well as Mannheimia/Pasteurella.

Cows and Bulls

Cows and bulls can also suffer from disease, and the impacts of disease in the cow herd can be financially devastating. Trichomoniasis is protozoa that can permanently infect bulls and temporarily infect cows to cause abortion. Losses to Trich can exceed $400/head and reduce your pregnancy rates by more than 60%. The best prevention is to work with your veterinarian to develop a Trich mitigation program centered on testing your bulls annually. Other diseases impact the cow directly, or like Trich, can cause pregnancy loss. Vaccinations can help prevent these diseases and also help the cow build quality colostrum when she gets ready to calve. Colostrum is antibody-rich milk that the calf requires in the first hours after birth; the calf relies on these antibodies for an immune system for the first few months of life. In fact, some work suggests that colostrum quality can impact calf health for months or even years after birth. Thus, it is important to not neglect your cow herd vaccination program. However, you must follow labels especially with MLV vaccines. In some cases, MLV vaccines may not be safe for pregnant cows if that cow has not been on a MLV vaccination program. This is yet another example of why you should consider consultation with your veterinarian to develop a health program. Some general annual recommendations are as follows:

- Long-acting antiviral vaccine that includes IBR and BVD. Including PI3 and BRSV may also be recommended
- Long-acting campylobacter fetus (vibrio)/leptospirosis (lepto) vaccine
- Treat for internal and external parasites
- Optional 7- or 8-way clostridial booster
- Trich test bulls
- Pregnancy test cows

Reproductive Management

If you are planning to start a seedstock or commercial herd, managing reproduction is critical for success. Reproductive problems are often the number one reason cattle will be culled from your herd and your reproductive rates will directly impact yearly income. Generally speaking, reproductive capacity or reproductive performance is lowly heritable which means environment and management have a significant impact on how your herd will produce. New Mexico's harsh environment should also influence how you think about and manage reproduction in your herd.

To get started, a cow's gestation period is approximately 285 days from breeding to calving. This is a rough estimate and can vary depending on environment, cow, bull, etc. It is well known that profitability is impacted by calving interval or days from calving until the next calf is born. The industry standard benchmark is to have every cow calve within 365 days of their last calf. That general guideline breaks down as follows: 285 days of gestation + 45 days postpartum recovery = 330 +/- days. A cow's reproductive cycle is 21 days (discussed below), so the goal is to get the cow pregnant, gestate, and allow sufficient time for the reproductive tract to reset after calving then get the cow bred within 2 and preferably 1 cycle. Reproduction is a tightly orchestrated and extremely complex event, but the take home message is that reproduction is a luxury. Your cow herd will only reproduce if they are well nourished and free of disease or other issues.

A cow's reproductive cycle is hallmarked by ovulation occurring approximately every 21 days. Preceding ovulation is a physiological event called estrus or heat. Follicles in the cow's ovaries develop in waves, and, when the hormone profile is correct, a follicle will mature to ovulate the ovum or egg. While the follicle is growing, it secretes a hormone called estrogen and estrogen influences the brain to signal the cow that it's almost time for breeding. Thus, the elevated levels of estrogen will cause the cow to seek other cows at a similar stage of the cycle and you will see them in a group mounting each other. Additionally, estrogen will make the cow stand to be ridden by either other cows or the bull; the cow that stands to be ridden is in estrus and often termed "standing heat." The cows that are mounting will likely be in standing heat within the next 24 hours or so. Ovulation will occur within 12-24 hours after standing heat, so it is critical that the cow be exposed to a bull during standing heat. If not, she will not be fertile for another 21 days.

Maintaining a yearly calving interval and optimizing when your cows calve during the calving season are two drivers of profitability in a beef operation. Maintaining a yearly calving interval is simply ensuring the cow calves every 365 days or fewer. In large pasture operations, essentially the only way to track yearly calving interval is to have a defined breeding season and check for pregnancy in the fall. If a cow does not maintain a yearly calving interval, her lifetime productivity is reduced. For example, a cow that is in the herd for 6 calving seasons but only calves every 430 days will have 1 fewer calf over those years than a cow that calves every 365 days. Even if a yearly calving interval is maintained, it is important to know when the cow calves within that year. Cows only display estrus and can become pregnant approximately every 21 days. Thus, calving distribution is the number of cows calving in 21-day periods during the calving season. The start of the 21-day window (termed calving period) each year is when the third mature cow has calved or approximately 285 days after the previous year's breeding season.

The primary factor associated with calving distribution and profitability is weight; cows that calve earlier wean heavier calves. Several experiments have evaluated calf weaning weights from calves born in the first calving period through the third calving period as would be the case in a typical operation with a 3-month breeding season. Table 1 shows the average weight difference and range for each calving period, and essentially every cycle that a cow misses getting bred costs approximately 40 pounds in weaned calf value. It is important to consider that a cow who breeds and subsequently calves every year in the first calving period has the same yearly cost as a cow that calves in the third period, yet the former will wean on average a calf that is 80+ pounds heavier at weaning.

Weaning Weight Difference for Calves Born in Different Calving Periods

	Calving Period 1	Calving Period 2	Calving Period 3
Average Weight Difference (lbs)	x	-40.3	-81
Range (lbs)	x	-29 to -46	-71 to -97

Table 1. Difference in weights of calves at weaning from three different calving periods. Every 21-day period accounted for approximately 40 pounds of weaning weight. Data are adapted from Lesmeister et al. (1973), Funston et al. (2012), and Cushman et al. (2013).

Managing for Reproduction

As complex as reproduction is, the overall management concept is simple: cows in good condition and health will reproduce. In earlier chapters, we discussed sourcing cows from successful New Mexico ranches. This recommendation largely centers on reproductive performance. If a cow does not match the environment, the first production characteristic to suffer is reproductive performance. Cows that are too large or produce too much milk will likely not be able to reproduce in limited forage situations. There are no tests to determine which cows can survive in this environment; only years of ranching and selection will determine that. The best recommendation to get started is to source good cows in your area and keep them in good condition. Also understand that what you read from other parts of the country may not be applicable to New Mexico. For example, the nationwide recommendation is to make sure your cows are in a body condition score of 5.5 at calving. In New Mexico, our springs can be pretty dry and often cows will calve and rebreed at lower body condition scores than cows in other parts of the country.

The cows and heifers that are still growing and trying to reproduce, as well as your older cows, will likely be your biggest challenge to keep productive. Young cows are still trying to grow to their mature body size, gestate a calf, and nurse a calf. The nutritional demands often exceed the rangeland capacity, thus reproduction in these classes of cattle suffer. In other parts of the US, the first-calf heifers and second-calf cows will achieve pregnancy rates similar to the rest of the herd. On New Mexico rangelands, it is not uncommon for 2- or 3-year-old cows to have reduced pregnancy rates. If you can manage these groups separately, it may be beneficial to feed them more in order to increase pregnancy rates. If you can't manage these groups separately, you would need to increase feed to the entire herd which means you are overfeeding the majority of your herd. Often, the economic return of increased pregnancy rates in the 2- and 3-year-old cows will not offset the cost of overfeeding the entire herd. You will need to evaluate this situation in your operation.

Again, the take home message is reproduction is a luxury that only occurs when the animal is in good nutritional status and good health.

Yearly Reproductive Management Schedule (Spring Calving)

Spring

- Any vaccinations recommended by your veterinarian. Some reproductive vaccines must be given close to the breeding season.
- Calve cows and monitor for health issues.
- Cull any cows that are open.
- Turn bulls into breeding pasture. Make sure to calculate when you want calving to start next year then back calculate to determine bull turn in date (remember gestation is 285 days, a cow's reproductive cycle is 21 days, and you want to give her at least a 90-day breeding season).
- Test bulls for Trichomoniasis prior to turnout (unless on fall schedule).
- Fertility test bulls prior to turnout.

Fall

- Administer annual vaccinations.
- Treat for internal and external parasites.
- Test cows for pregnancy and cull any non-pregnant cow older than 3 years old.

Year-round

- Monitor body condition and ensure cows are in good health.
- Near calving increase supplementation as needed.
- Monitor for health issues.

Reproductive Technologies

There have been numerous advancements in reproductive technologies over the last 20 years. Perhaps the most significant development has been optimizing reliable heat synchronization protocols which allows managers to time the breeding of their cow herd. This a powerful tool that has many applications. Essentially, a series of treatments are administered to your cows and you can then either use natural service or a technology called artificial insemination to breed your herd. At the end of this chapter, the approved heat synchronization protocols are provided complimentary of the Beef Reproductive Task Force.

Artificial insemination is a technique where frozen bull semen is thawed and administered to the cow 12 hours after standing heat or at a specific time following hormone treatment. There are several advantages to artificial insemination. First, for smaller herds, if you become trained to do artificial insemination yourself, you can breed your herd without needing to maintain bull(s). Additionally, it is more economical to purchase semen straws from exceptional sires than spend large amounts of money to purchase a bull of similar quality. Through synchronization and artificial insemination, your calving season will also be condensed, thereby optimizing calving interval and distribution. New Mexico State University and others in industry offer the opportunity to receive training in artificial insemination techniques.

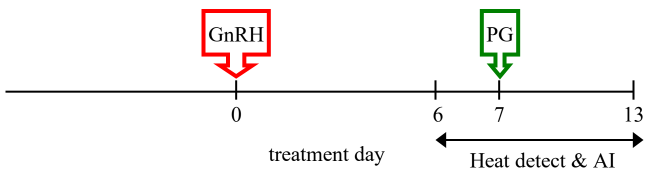
Embryo transfer is another reproductive technique used to amplify the genetics of exceptional females. Embryo transfer is primarily used in the seedstock and show industries. Very briefly, the exceptional female is exposed to a series of hormone shots to induce her to ovulate multiple eggs. After breeding, the embryos are flushed from this donor cow and then either transferred to another recipient cow or frozen for future use. Another technique involves aspiration of eggs from the ovary and then fertilizing the eggs in a petri dish; this technique is known as in vitro fertilization. The resulting embryos are either transferred to recipient cows for gestation or frozen for future use. Effectively, this allows you to have multiple calves from a single cow in a year or store her genetics for future use.

Beef Reproduction Task Force

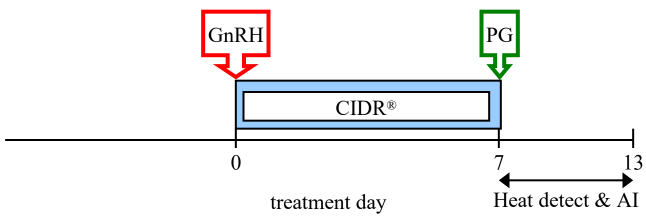
BEEF COW PROTOCOLS - 2022

HEAT DETECTION

Select Synch

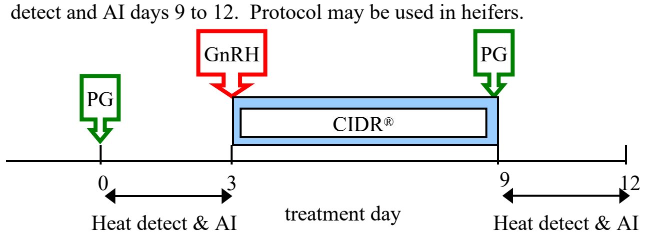


Select Synch + CIDR®



PG 6-day CIDR®

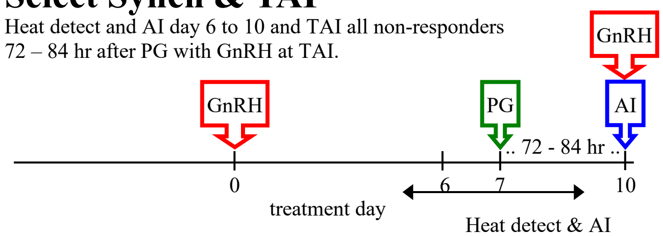
Heat detect and AI days 0 to 3. Administer CIDR to non-responders and heat detect and AI days 9 to 12. Protocol may be used in heifers.



HEAT DETECT & TIME AI (TAI)

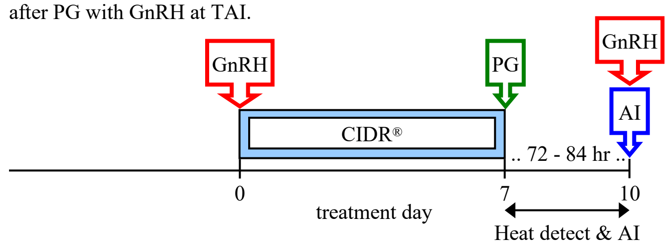
Select Synch & TAI

Heat detect and AI day 6 to 10 and TAI all non-responders 72 – 84 hr after PG with GnRH at TAI.



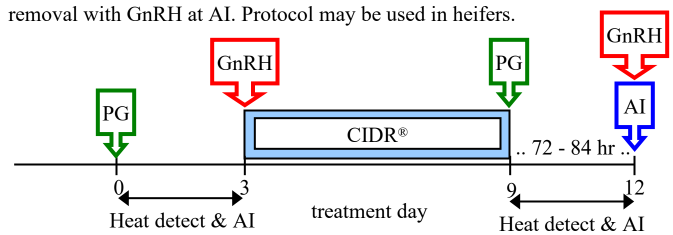
Select Synch + CIDR® & TAI

Heat detect and AI day 7 to 10 and TAI all non-responders 72 - 84 hr after PG with GnRH at TAI.



PG 6-day CIDR® & TAI

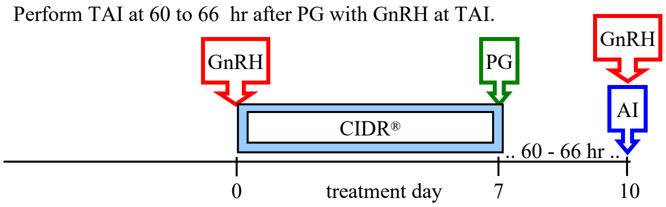
Heat detect & AI days 0 to 3. Administer CIDR to non-responders & heat detect and AI days 9 to 12. TAI non-responders 72 - 84 hr after CIDR removal with GnRH at AI. Protocol may be used in heifers.



FIXED-TIME AI (TAI)*

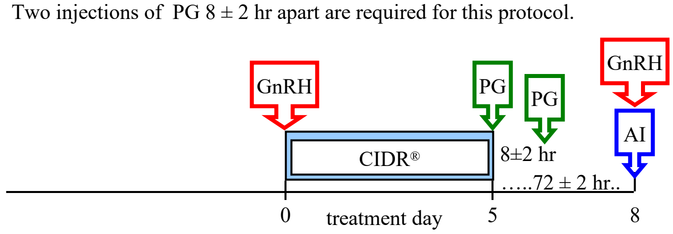
7-day CO-Synch + CIDR®

Perform TAI at 60 to 66 hr after PG with GnRH at TAI.



5-day CO-Synch + CIDR®

Perform TAI at 72 ± 2 hr after CIDR removal with GnRH at TAI.
Two injections of PG 8 ± 2 hr apart are required for this protocol.

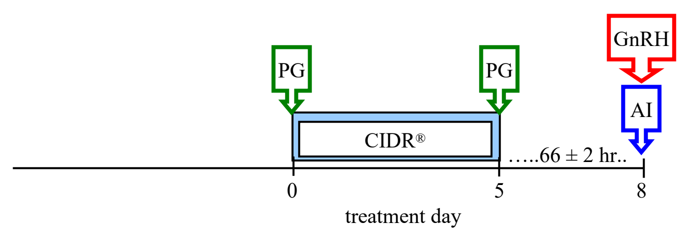


FIXED-TIME AI (TAI)*

for *Bos Indicus* cows only

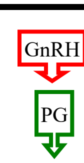
Bos Indicus PG 5-day + CIDR®

Perform TAI at 66 ± 2 hr after CIDR removal with GnRH at TAI.



* The time listed for "Fixed-time AI" should be considered as the approximate average time of insemination. This should be based on the number of cows to inseminate, labor, and facilities.

These protocol sheets were assembled by the ***Beef Reproduction Task Force; BeefRepro.org***. Programs are intended to promote sustainable food production systems by the beef industry through sound reproductive management practices for replacement heifers and postpartum cows. The Beef Reproduction Task Force recommends working with a licensed veterinarian for proper use and application of all reproductive hormones. **Approved 12-1-2021**.



Cystorelin®, Factrel®, Fertagyl®, OvaCyst®, GONABreed®

estroPLAN®, Estrumate®, In-Synch®, Lutalyse®, Lutalyse® *HighCon*, ProstaMate®, SYNCHSURE™

Supplementation for Beef Cattle Grazing Western Rangelands

Providing supplemental nutrients to cattle grazing western rangelands is practiced commonly, and for good reason. Ruminants often are unable to consume enough nutrients from rangelands to fulfill their requirements for maintaining acceptable production levels. During such situations, supplemental feeding is necessary. Producers have many choices of commercial feed supplements and an unlimited number of options for developing custom supplements. Therefore, it can be difficult to decide which supplement type (energy or protein) best fits the goals of the livestock production system. A fundamental understanding of ruminant nutrition is also helpful in making these decisions. The objective of this publication is to clarify the relationship between protein and energy use by cattle, and to address protein and energy supplementation for grazing beef cattle.

General Ruminant Nutrition

Ruminants are different from pigs, horses, and humans in that they have a rumen in which ingested feedstuff is fermented before it reaches the stomach (called the abomasum in the cow). The rumen provides an optimal environment for the existence and growth of microorganisms. These rumen microorganisms break down, or digest, some of the feed that is ingested by the ruminant and use it for energy to support microbial growth. At the same time, rumen microorganisms release volatile fatty acids, which the ruminant animal uses as its major source of energy.

The bodies or cells of the rumen microorganisms eventually pass out of the rumen. Once they reach the small intestine, they can be digested by the ruminant. Because these cells contain approximately 50% protein, they con-tribute to the animal's protein supply. This symbiotic relationship between the ruminant and the microorganisms allows ruminants to use forage much more efficiently than non-ruminants. Additionally, this relationship adds to the complexity of predicting and effectively meeting the nutrient requirements of ruminant animals.

Nevertheless, it is clear that ruminants must have energy to survive. However, it is the microorganisms in the rumen that must unlock (digest) the energy in the forage to make it available to the ruminant. To digest forage, the microorganisms must have nitrogen, which is primarily found in protein.

Ruminal Protein Requirements

Rumen microorganisms synthesize an estimated 0.12 pounds of bacterial crude protein from 1 pound of total digestible nutrients (TDN, an estimate of energy supply to the animal; NASEM, 2016). An inadequate supply of protein from dormant forage can result in reduced microbial protein production, reduced forage digestion, and an unrecoverable loss of nutrients. Coupled with an unbalanced supply of metabolizable nutrients for the animal tissues, these changes can lower forage intake and cattle performance. Providing a balanced, or in some instances an unbalanced, supply of nutrients to the rumen is a key to obtaining the desired intake and production response. The relationship between protein and energy illustrates the importance of ensuring that the nutrient supply in the rumen does not limit microbial activity.

Forage Supply And Composition

The availability of forage and its chemical composition (primarily crude protein) are the first factors to consider in developing an effective range nutrition program. If the objective of a range nutrition program is to meet the nutrient requirements as economically and efficiently as possible, the first limiting nutrient must be identified and cost-effectively supplemented. Research has clearly demonstrated that with mature beef cows, the decision to feed a protein, energy, or combination supplement should depend on forage supply and protein content, and cow body condition.

Reference NMSU Extension publication CR575 Managing and Feeding Beef Cows Using Body Condition Scoring (https://pubs.nmsu.edu/_circulars/CR575/index.html) NMSU's Corona Range and Livestock Research Center (CRLRC), located near Corona, NM, has been monitoring forage quality on the ranch for over 20 years. Figure 1 is a graph that depicts crude protein con-tent of the forage in good-, average-, and low-quality years compared to a heifer's protein requirement.

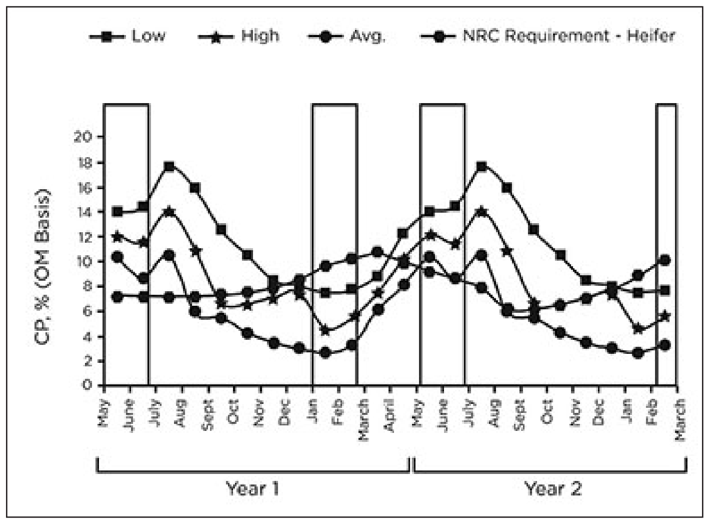


Figure 1. Protein content of CRLRC forage versus heifer protein requirements over time. (Data provided by Dr. Eric Scholljegerdes, Department of Animal and Range Sciences, NMSU.)

Even in good years, protein supplementation is warranted when forage is dormant. If heifers are run in the same pasture as mature cows, supplementation strategies should be designed to meet the needs of the heifer because her requirements are greater (10% CP vs. 8% for cows). Testing winter pasture forage in the fall after the first hard freeze will provide a starting point to develop a supplementation plan for that year.

Forage testing

Forage samples should be collected away from water sources, mineral locations, and away from roadsides. It is ideal to collect approximately ½ to 1 pound of forage in areas where cattle typically graze. There are several laboratories in the country that can analyze feed and forages for a wide range of nutrients. Protein and energy (TDN) values from the forage analysis are the key bits of information that are best to determine supplementation needs.

Diet Selection

Cattle that are grazing native rangelands with a diverse plant population can be relatively selective about what they eat. This is most important when forage becomes dormant and the protein content declines. In general, cattle grazing dormant native range select a diet that is about 1.5 to 2 percentage units higher in crude protein content than the average of the standing forage in the pasture.

For example, cows grazing native range in which the forage has an average protein content of 4% generally select a diet that is 5.5–6% crude protein. However, cattle grazing less-diverse pastures, such as improved pastures containing only one or a few grass species, cannot be as selective, so the crude protein con-tent in their diets is more similar to the average of the pasture's standing forage.

Protein Supplementation

Forage Intake

Daily energy intake is the primary factor limiting cattle performance on forage diets. In many instances with warm-season perennial forages, and possibly with cool-season perennial forages at advanced stages of maturity, there is an inadequate supply of crude protein, which effectively limits energy intake. An example of the relationship between crude protein content of forages and forage intake is presented in Figure 2. Intake declines rapidly as forage crude protein falls below about 7%, a relationship attributed to a deficiency of nitrogen (protein) in the rumen, which hampers microbial activity.

If the forage diet contains less than about 7% crude protein, feeding a protein supplement generally improves the energy and protein status of cattle by improving their forage intake and digestion. at a crude protein content of 5%, forage intake is about 1.6% of body weight, while at 7% crude protein, forage intake is 44% higher at 2.3% of body weight.

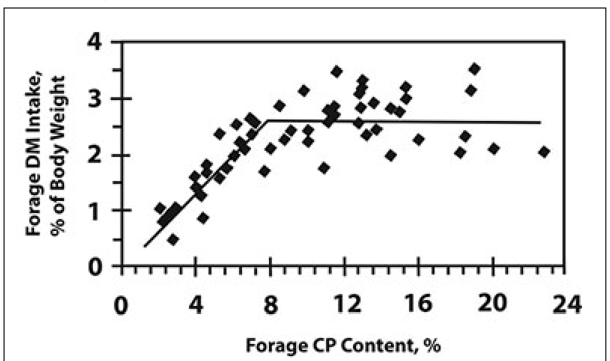


Figure 2. Relationship between forage crude protein content and forage intake.

Improved forage intake boosts energy intake, which demonstrates why correcting a protein deficiency is usually the first supplementation priority. For example, Table 1 shows the estimated impact of protein supplementation on energy status. Forage in-take increased 30% in response to a modest amount of protein supplement (0.18% of body weight), resulting in a 49% increase in TDN (energy) intake by the cow.

Impact of Protein Supplementation on the Energy Status of a 1,000-pound Cow

	Unsupplemented	Supplemented	Change
Forage crude protein, %	5	5	
Forage TDN*, %	45	45	
Supplement crude protein, %		42	
Supplement TDN, %		76	
Supplement intake, lb	0	1.8	
Forage intake, lb	16	20.8	+30%
Total daily intake, lb	16	22.6	+41%
Total diet crude protein %	5	7.9	
TDN intake, lb	7.2	10.7	+49%

Table 1. An example of the impact of protein supplementation on the energy status of a 1,000-pound cow. *TDN = total digestible nutrients. Adapted from McCollum (1997).

The crude protein content of some forages must drop to about 5% before intake declines. However, intake of other forages may decline when forage crude protein drops to 10%. Part of the variation can be attributed to differences in nutrient requirements of the cattle, with the remainder attributed to inherent differences among forages that provide differing proportions of nutrients to rumen microorganisms. Response of intake to a single nutrient such as crude protein would not be expected to be similar among all forages.

Sources of Supplemental Protein

Supplemental protein is available in many forms. Feed-stuffs and formulated feeds containing from less than 10% crude protein to more than 60% crude protein are available. To complicate things further, crude protein may come from a natural protein source, a non-protein nitrogen source, or a mixture of the two. An additional consideration may be the ratio of ruminally degradable protein to escape protein (commonly referred to as bypass protein).

Crude Protein Content of Supplements Research has established a correlation between supplement protein content and total forage intake when forage quality drops below 7% crude protein (Table 2; Heldt, 1998). If the objective is to optimize intake and digestion of low-quality forages, it is easy to see that supplements should contain more than 30% crude protein, although supplements containing less than 30% crude protein may yield a slight enhancement in forage intake.

Improvement in Low-Quality Forage Intake

Supplement Protein Content, %	Improvement in Forage Intake Above Unsupplemented, %
Less than 15	3
15-20	10
20-30	21
Greater than 30	44

Table 2. Average Improvement in Low-Quality Forage Intake in Response to Various Crude Protein Concentrations. Source: Heldt (1998).

Escape Protein Versus Ruminally Degradable Protein

Escape protein is protein that is not degraded in the rumen and thus escapes to the small intestine where it can be digested. Plant-based protein concentrates, such as cottonseed meal and soybean meal, generally contain 55–70% ruminally degradable protein and 30–45% escape protein.

In a situation where forage is abundant, forage protein content is low, and the objective is to stimulate or sustain forage intake, ruminally degradable protein is the first priority because the rumen microorganisms need additional nitrogen. Feeding cattle a supplemental protein source with high "escape" potential may not stimulate ruminal activity, so forage intake and performance response to supplementation may be less than if the cattle were fed a supplement with a higher proportion of ruminally degradable protein.

Research results favor using ruminally degradable protein sources over escape protein sources for cattle consuming low-protein forages. When forage supply is abundant but low in protein, it is recommended that 60–70% of the supplemental protein be ruminally degradable, and that the total diet contain 0.11–0.13 pounds of ruminally degradable protein per pound of TDN.

Table 3 represents an example of a calculation for estimating the amount of supplemental ruminally degradable protein needed by an 1,100-pound cow grazing an abundant supply of low-quality forage (5.5% protein). In this example, the deficiency in ruminally degradable protein is approximately 0.45 pounds. It would take approximately 2 pounds per day of a 40% protein cotton-seed meal-based supplement to fulfill this requirement. When feeding a traditional 20% range cube, feeding rates would need to be doubled (4 pounds per day)

However, there is typically a diminishing return to protein supplementation. The first increment of supplemental protein typically accounts for a proportion-ally larger percentage of the potential improvement in performance than do later increments. Research has determined that the majority of the improvement in performance results from providing supplemental protein equivalent to about 30–40% of the actual protein deficiency.

Daily Supplemental Protein Needed

Component	Quantity
Forage intake, lb[a]	20
Forage TDN[b], %	55
Forage CP[c], %	5.5
Ruminally degradable protein, % of CP	55
Diet TDN, lb	11
CP in selected diet, %[d]	7.5
CP in the diet, lb	1.5
Ruminally degradable protein requirement, lb[e]	1.27
Diet ruminally degradable protein supply, lb	0.82
Supplemental ruminally degradable protein needed, lb	0.45

Table 3. Sample Calculation of Daily Supplemental Protein Needed to Meet the Ruminally Degradable Protein Requirement of an 1,100-pound Cow Grazing an Abundant Supply of Low-Quality Forage. a. Estimated at 1.8% of body weight per day. b. TDN = total digestible nutrients. c. CP = crude protein. d. Estimated at 2 percentage units above pasture average. e. Based on NASEM (2016) guidelines (ruminally degradable protein required as 65% of total CP intake).

In the example in Table 3, although the cow needs 0.45 pounds of supplemental ruminally degradable protein, the majority of the potential response to supplementation generally can be achieved by providing only about 65% of the estimated deficiency. This would be equivalent to about 0.3 pounds of ruminally degradable protein and about 1.5 pounds of a 40% protein cottonseed meal-based supplement, or 3 pounds of a 20% range cube product. If performance remains suboptimal at this quantity, then it may be necessary to provide additional protein.

If supplying ruminally degradable protein does not improve production, then supplying escape protein may help. This is especially true for beef cattle with high protein requirements due to lactation, growth, or lactation and growth combined. Often, forages contain 12–20% crude protein that is highly degradable in the rumen (ruminally degradable protein >70% of crude protein). The high degradability of the forage protein may result in a relatively large portion of the nitrogen being absorbed across the rumen wall without being converted to microbial protein. This absorbed nitrogen cannot be used completely by the animal. Therefore, it may be necessary to provide a supplement that is high in escape protein (50%) to meet the animal's protein requirements. In some instances, cattle grazing high-quality forages that are fed a supplement high in escape protein have improved both their forage intake and weight gain.

Research conducted at NMSU has evaluated the effects of escape protein fed to cows and heifers in marginal body condition grazing dormant New Mexico rangelands (4–6% crude protein). A series of several studies demonstrated that escape protein supplements may play a role in energy metabolism and reproductive efficiency in young cows grazing native forage. Supplements containing anywhere from 20–50% undegradable intake protein (UIP) as part of the crude protein source resulted in less weight loss post calving, shorter postpartum intervals, and improved milk production and pregnancy rates (Hawkins et al., 2000).

It is important to note that supplements with high concentrations of escape protein can be expensive. A good alternative is supplementing with dried distillers grain. This economical by-product from the ethanol industry typically tests at 28–30% crude protein, of which approximately 70% is considered bypass protein. Research has shown improvement in body weight and pregnancy rates, and reductions in post-partum intervals in young cows (Engle et al., 2008; Martin et al., 2007). The same result may also be achieved by providing more of a protein supplement that has a lower concentration of escape protein such that the same amount of escape protein is provided, or by providing a supplement with a higher energy content.

Urea or Biruet Usage in Protein Supplements

At times, non-protein nitrogen in the form of urea can be a less-expensive source of protein. Urea is used directly by rumen microorganisms as a source of nitrogen and is completely ruminally degradable. However, this source of nitrogen is very unpalatable and should be used in moderation. Because urea has a much higher concentration of nitrogen than protein, the protein equivalence of urea is 290% (1 pound of urea is equivalent to about 2.9 pounds of protein based on nitrogen content).

Research conducted at Kansas State University indicates that at times, urea can be used to reduce protein supplement costs without causing negative effects on performance—as long as not more than 25% of the ruminally degradable protein in the diet is supplied by urea (Woods, 1997). Including higher concentrations of urea in protein supplements reduces the supplement palatability and ultimately suppresses intake and animal performance. If urea-containing protein supplements are fed less frequently than every other day or are fed to lactating cows, urea should not supply more than 15% of the ruminally degradable protein in the supplement. It is recommended to purchase prepared feed with urea or biuret additions to ensure not too much is delivered to the animal.

It should be noted, however, if you market your cattle as all natural, these feed additives are prohibited to use in all-natural programs. Be sure to read prepared feed labels carefully.

Energy Supplementation

When performance is limited by energy intake and forage protein content is not limiting microbial activity, the best option is to increase the energy intake directly with an energy supplement (low pro-tein, high energy) if it is not possible to correct the short supply of energy by reducing stocking rates. Typically, energy supplements are less expensive per unit than protein supplements, but the response to energy supplementation can be variable and difficult to predict.

Substitution with Energy Supplements

A common frustration with feeding energy sources is the "substitution effect." This occurs when the supplemental feed substitutes for forage by reducing forage intake. One of the main concerns when providing energy supplements to grazing beef cows is the starch content of the supplement. Research has shown that when high-starch supplements (such as corn, grain sorghum, wheat, or barley) are fed to cattle consuming forages (especially when protein is deficient), forage intake and digestion are often suppressed, ultimately reducing the energy derived from the basal forage diet. Therefore, to truly "supplement" energy, highly digestible fiber sources (such as soyhulls, wheat bran, wheat middlings, or corn gluten feed) are generally most desirable.

Any time substitution occurs, the energy intake of the animal may not increase to the desired level be-cause of a concomitant reduction in forage intake. As a general rule, 1 pound of an energy-dense feed reduces forage intake by 0.5–1 pound. The substitution rate depends on forage protein content, level of protein in the supplement, type of energy sources, and feeding rate. The substitution rate increases as forage protein content increases, the rate decreases as the level of protein in the supplement increases, and the rate tends to increase as supplement intake increases.

Feeding high levels of hay can also result in substitution. As the amount of hay fed daily increases, forage intake from the pasture decreases because fill from the hay replaces fill from the pasture.

Sources of Supplemental Energy

To sustain or possibly improve the current level of forage intake but increase the total daily energy intake, a supplement with a moderate level of protein will be required to ensure an adequate supply of ruminally degradable protein. Additionally, the quantity of high-starch feedstuffs should be limited. Instead, energy supplements should consist of highly digestible fiber sources. However, using highly digestible fiber sources for energy supplementation does not eliminate the possibility of substitution.

Feeding Rate

Feeding low-protein, energy-dense supplements at rates of less than 0.3% of body weight per day (3.3 pounds/day for an 1,100-pound cow) typically has no negative impact on forage intake and may even yield an increase. However, as the feeding rate increases, forage intake generally begins to decline due to substitution, so performance may not in-crease as rapidly as expected because the decrease in energy supplied by the grazed forage diet often is overlooked.

Frequency Of Supplementation

Feeding frequency (daily versus three times per week versus once per week) can affect animal response. Feeding smaller amounts of protein or energy supplements more frequently decreases the potential for negative impacts on forage in-take. However, research conducted at NMSU that evaluated infrequent delivery of high-protein supplements revealed no significant reductions in heifer performance when supplemental protein was fed one time per week as compared to three times per week (Table 4). Additionally, transportation and labor costs were reduced by approximately 60%. NMSU researchers have also demonstrated that heifer performance (weight gain and conception rate) significantly declined when the frequency of energy supplementation was decreased from daily to twice per week (Table 5).

Figure 1. Hand-feeding is an excellent method to control livestock location and movement, while minimizing variation in supplement intake.

Supplementing the Same Amount of Cottonseed Cake

Component	Year 1		Year 2	
Times fed/week	1	3	1	3
Amount fed/feeding, lb/hd[b]	6.9	2.3	10.5	3.5
Protein fed/feeding, lb/hd	2.8	0.95	4.3	1.43
Number of heifers/treatment	43	40	27	18
Average initial weight, lb	495	495	502	491
Average daily gain, lb	0.50	0.47	0.34	0.37
Conception rate, %	93	90	89	89

Table 4. Comparison of Supplementing the Same Amount of Cottonseed Cake (41% CP[a]) to Yearling Heifers Once Weekly Versus Three Times Weekly During the Winter-Spring Dormant Season of Two Consecutive Years. a. CP = crude protein. b. hd = head. Adapted from Wallace and Parker (1992).

Grain Cubes for Energy Supplementation

Component	Grain Cube (9.4% CP[a])	
Times fed/week	2	7
Supplement fed, lb/hd[b]	6.4	1.8
TDN[c] fed/feeding, lb/hd	5.34	1.52
Average daily gain, lb/day	-0.03	0.14
Conception rate, %	68	94
Supplement cost, $/hd	$23	$23

Table 5. Comparison of Grain Cubes for Energy Supplementation of Yearling Heifers Either Daily or Twice Weekly for 156 Days During the Winter-Spring Dormant Season a. CP = crude protein. b. hd = head. c. TDN = total digestible nutrients. Adapted from Wallace and Parker (1992).

Example Situations

Situation 1: Forage supply is abundant and protein content of the native range is 5% or less.

In this situation, cows should be able to select a diet that is 6.5–7% crude protein. Therefore, supplemental protein is necessary and should increase forage intake and possibly forage digestion. A small quantity (0.5–1 pound/day) of high-protein supplement (>30% protein) is typically the most economical supplement to use in this situation. If cows are mature, the protein in the supplement should be around 55–70% ruminally degradable. Most commercial feed supplements (i.e., range cubes) on the market today will meet these benchmarks. At this rate, both the nitrogen requirements of the rumen microorganisms and the protein requirements of the cow should be fulfilled. However, if the protein content of the native range is less than 4%, a larger quantity of supplemental protein may be necessary.

Situation 2: Forage supply is limited and protein content of the native range is above 5%.

In this situation, cows should be able to select a diet that is adequate in protein content (7%), meeting the needs of both the rumen microorganisms and the beef cow. This situation is not uncommon during droughts. Often, the most cost-effective solution to this problem is to lease pasture in another area so that stocking rates can be reduced to levels where forage supply is not limiting and very minimal supplementation is necessary.

However, a producer may want to provide supple-mental energy to the cows instead. This is a situation where a low-protein, high-energy supplement is re-quired. If the goal is to supplement without substitution, then a highly digestible fiber source is desirable. Providing energy in the form of a supplement high in soyhulls, wheat bran, or wheat middlings may yield the desired results if supplementation does not exceed about 4 pounds per day. Supplementation above that level probably will result in some substitution. Additionally, energy supplements of this nature should be fed at least every other day.

In cases of limited forage supply, the goal may be to provide additional energy and reduce the amount of forage harvested from the range by the cows. In this situation, an energy substitute would be beneficial. Substitution can typically be accomplished by feeding large quantities (>0.5% of body weight) of hay or any other digestible energy source (such as corn or grain sorghum).

Situation 3: Forage supply is unlimited and protein content of the native range is above 5%.

Cows should have enough available energy and should be able to select a diet that is adequate in both energy and protein content (7%), meeting the needs of both the rumen microorganisms and the beef cow. This is an ideal scenario that requires no intervention.

Situation 4: Forage supply is limited and protein content of the native range is less than 5%.

Cows are not able to select a diet that is adequate in energy or protein content. Unfortunately, this situation is relatively common throughout the western United States. In this case, a combination supplement ranging from 20–30% crude protein should be provided. Although alfalfa hay generally does not fit in this range, it may be a practical alternative if it is provided at 5–10 pounds per day. However, as forage supply decreases, the protein content of the supplement should also decrease so that the energy content of the supplement can supply more energy per unit of supplement. Additionally, as the protein content of the supplement decreases, the per-unit cost of supplement should decrease.

Supplementation Management

Feed costs can represent up to 70% of a cow's annual input cost. However, in order to maximize productivity, supplementation is needed during certain times of the year to help meet nutritional requirements and prevent weight loss. Range forages are often deficient in protein and energy during plant dormancy. Forages may also be deficient in a variety of minerals all year long. Therefore, these are the nutrients most commonly provided in supplements. To efficiently meet nutritional requirements, it is important to choose a delivery method that provides the targeted amount of desired nutrients to each animal in the herd. Ideally, this is achieved with minimal input costs for labor, equipment, and supplemental feed. A variety of factors influence the usefulness of a particular delivery method. The objective of this circular is to describe some of the supplement delivery methods available to livestock producers and to discuss their advantages and disadvantages.

Hand-Feeding Versus Self-Feeding

Figure 2. Self-fed supplement delivery can be an effective way to provide nutrients to livestock (photo by Win Henderson, FEMA).

Supplement delivery methods can be broadly classified as hand-fed or self-fed systems. Hand-feeding implies that the supplement is regularly delivered to the animals in a form and amount that is immediately consumed. Self-fed supplements are made available in bulk amounts at infrequent intervals (Figure 3), with the expectation of continuous, low-level consumption by livestock.

Self-fed supplements are designed to limit intake so that animals consume only small portions of the available feed at each meal. Intake may be limited by the supplement's physical form (e.g., hardened molasses blocks), a palatability factor (salt, phosphoric acid, etc.), or a combination of these elements.

Self-fed supplements have several advantages. They can reduce labor costs since delivery times are designed to be less frequent than with hand-feeding. If supplements are to be consumed at low amounts (e.g., mineral supplements), then self-feeding may be very cost effective. Another advantage of self-feeding systems are that animals can consume supplement every day. This is mainly an advantage with energy or mineral supplements.

The design of feed troughs or bunks for self-feeding systems is important for several reasons. Intake limiters, such as salt or phosphoric acid, may corrode metal feeders, reducing their useful life. Constructing troughs that last longer may reduce portability and limit flexibility in location of feeding areas.

There are some disadvantages to self-feeding systems to consider when weighing options. If livestock are checked at times other than feeding, the savings in labor and associated costs may be less than expected. For supplements that are targeted for more than 1 lb per day consumption, weekly delivery may still be required due to lack of feed bunk volume or the desire to keep feeds fresh. Also, if there is a reduction of total available forage (e.g., due to drought), animals will over-consume these supplements, which can result in digestive upset and reduced performance. Therefore, self-feeding systems for energy supplements specifically may not be appropriate every year.

Based on this comparison, if a self-fed supplement costs significantly more than a hand-fed supplement, any labor cost savings may be offset. However, for energy or mineral supplements (which require daily or alternate day feeding), self-fed supplements may be more economical, even at a higher price per ton, because both labor and transportation costs are reduced. Furthermore, in rough or poorly accessible areas, self-fed supplements may be the only viable solution since the producer may have limited ability to deliver feed to the animals.

Hand-feeding is often used as a method to control livestock location and movements. This may be an advantage or a disadvantage, depending upon circumstances. When animals become accustomed to coming to a vehicle and receiving feed, they may be easier to gather and/or check. However, on public land or private land with easements, animals may begin following all vehicles, which can be a problem. In this situation, self-fed supplements may be more desirable.

Scientists at both New Mexico State University and Texas A&M University's San Angelo Experiment Station have shown that hand feeding protein supplements once a week results in the same level of performance as feeding three times per week or daily (Huston et al., 1999; Wallace et al., 1992). Therefore, when supplementing protein, the labor required for hand-feeding can be similar to self-feeding (Table 6).

Labor Cost Comparison of Hand-fed and Self-fed Supplements for One Week

Item	Daily	3x per week	1x per week	Self-fed[a]
Vehicle Costs[b]				
Feeding	$121.80	$52.20	$17.40	$0
Checking cows[c]	$0	$0	$17.40	$34.80
Labor costs				
Feeding[d]	$168.00	$72.00	$24.00	$0
Checking cows[e]	$0	$0	$18.00	$36.00
Totals	**$289.80**	**$124.20**	**$76.80**	**$70.80**

Table 6. Labor Cost Comparison of Hand-fed and Self-fed Supplements for One Week a. Self-fed supplement delivered to the pasture by the feed dealer. b. Vehicle cost of $0.58/mile; assumes a 30-mile round trip. c. Expenses for checking cows are included in daily and 3× weekly feeding. Additional costs will be incurred when feeding 1× weekly or self-fed. d. Labor cost of $12.00/hr. Feeding requires 1 hour of driving and 1 hour for feeding. e. Checks require 1 hour of driving and 0.5 hour observing cows.

Feeding Technology

Many new technologies have come on the market that address some of the challenges associated with supplementing cattle on range. There are now state of the art self-feeding delivery systems that track and regulate daily intake of supplement. Through electronic ear tag identification, cattle will be allotted a fixed rate of feed per day; if an animal attempts to exceed that allotment, they will not be given access to the feed. Another system will dispense a set amount of feed and automatically call cattle to the feeder using a noise-making device. Though these automated systems are designed to reduce time and control feed costs, the cost of maintaining them may outweigh the savings in feed and labor. This should be considered before purchasing these kinds of systems.

Even with this precise intake regulation, self-feeding systems like these have some of the same issues as traditional feeding. The day to day variability in intake per animal, along with the percentage of animals that do not utilize the feeders at all, can result in reduced performance and efficiency (Williams et al., 2018).

Supplement Form

The practicality of supplement delivery systems on a particular ranch is often strongly influenced by the form (e.g., cake, block, liquid) of the supplemental feed. The various forms of supplements each offer advantages and disadvantages. This section will cover the forms of supplements available, how they are fed, and important considerations for producers regarding each form.

Dry Feeds

Dry feeds are primarily composed of dry ingredients combined to meet nutrient specifications (some dry feeds include a small amount of molasses to improve palatability and binding characteristics). These feeds can be further processed into various forms or left as an unprocessed mix (meals). A potential advantage of all dry feeds is flexibility in formulation. Once nutrient specifications are determined, a formulation based on the cheapest combination of ingredients can be created to minimize cost. For example, if cottonseed meal becomes expensive, then another protein source like sunflower meal might be easily substituted into the formula.

Meals

Meals typically are combinations of dry ingredients mixed together with no further processing. Meals are a common form of range mineral supplements because ingredients in these supplements are difficult to bind together, and the loose form encourages consumption. However, overconsumption is also more common with some meal forms of supplement. Salt is an ingredient that is commonly used to limit meal intake. It is easy to include in order to regulate self-feeding supplement consumption. Salt-limited protein meals have been used successfully in the past. Animals may develop a tolerance to salt over time (and increase intake of the supplement), but with meal supplements, producers can add salt by hand to adjust intake to desired levels. This is an advantage for a self-feeding program.

A disadvantage of meals is that they must be placed into some type of trough or feeder because feeding on the ground results in excessive waste of supplement. Fortunately, since mineral supplements are delivered in relatively low quantities, only a small investment in storage and trough space is required. For energy and protein supplements, more trough space is required, and therefore a potentially larger investment in equipment is needed.

Crumbles

Crumbles are dry feeds that are mixed and pelleted, then crushed to produce smaller particles. Crumbles are most often associated with poultry feeds, but some manufacturers have produced mineral supplements in this form. These mineral supplements have been marketed as having higher environmental (wind and moisture) resistance than loose mineral meals. Research from New Mexico State University indicates that wind losses are minimal with loose mineral mixes (Dean et al., 1999). Therefore, this benefit may only be realized in extremely windy locations. Crumbles may reduce sifting of fine materials and leaching of ingredients due to precipitation, but this has not been well documented for mineral supplements.

Cubes/cake/pellets

Cubes, cake, or pellets all refer to essentially the same feed form. Cubes, the most common form of dry feed used for hand-fed range protein supplements, are available in a variety of sizes. They can be ordered in bulk for distribution by a bulk feeder or purchased in sacks. Bulk feeds reduce the labor associated with handling and often reduce the price of the supplement, but they require a relatively large initial in-vestment in storage and equipment. Pellet feeding allows some control over livestock distribution since animals can usually be led to a desirable feeding area. Cubes are often fed on the ground, but this may be difficult in snow or mud. For hand-fed supplements, cubes usually have the lowest variation in supplement intake by animals (Bowman et al., 1997). This is especially evident when feed is provided three or fewer times per week (Huston, 2000).

A few manufacturers offer self-fed cubes that include an intake limiter (usually salt). As with other self-fed supplements, a feeder is required. This type of self-feeding system may be acceptable under some conditions. How-ever, animals may develop a tolerance for the intake limiter, and intake may increase over time. With self-fed cubes, it is difficult for producers to adjust intake by adding salt since particle size differences will result in sorting.

Dry or pressed blocks

Dry or pressed blocks are essentially very large cubes. These blocks offer similar advantages for formulation flexibility as other dry feeds. Blocks offer an intermediate option between a true self-fed system and a hand-fed system. They can be manufactured with varying degrees of hardness to influence supplement intake. Harder blocks reduce intake, while softer blocks increase intake. Depending on the targeted intake amount, proper hardness can be determined, and the blocks can be used as a self-fed supplement. Blocks that are excessively hard may result in poor consumption or even tooth damage and loss, while extremely soft blocks may encourage overconsumption of supplement.

Regardless of the delivery frequency, old blocks should be completely eaten before the new ones are delivered to ensure adequate nutrient intake. Individual animal consumption of blocks may be more variable than cubes or meals of the same formulation (Kendall et al., 1983). However, according to a review conducted by Montana State University researchers, the number of non-eaters is still relatively low and similar to that of pelleted supplements (Bowman et al., 1997). In principle, block feeding allows more timid animals the opportunity to consume the supplement since they can wait until other animals have left the feeding area.

The compact size and shape of blocks may make handling easier, reducing labor and mileage requirements. For example, if more blocks can be loaded than cubes, then producers may not need to return to the storage site when delivering feed to several areas of the ranch.

Liquid Feed

Liquid feed use has grown significantly in the past 20 years. Liquid feeds for range use are almost exclusively self-fed products and have many of the same advantages and disadvantages of other self-feeding systems (Figure 4). Many liquid feed dealers offer a delivery service, which can eliminate the labor and handling requirements associated with supplementation (as shown in the example of Table 6).

Figure 4. Liquid supplements in lick tanks large enough that they are filled less than once a week.

However, feed dealers account for their delivery cost when pricing these products, so ranchers must carefully examine the cost of labor and cost per unit of nutrient delivered.

A potential drawback with liquid feeds is the limited number of ingredients that can be utilized in formulations. While this may stabilize prices, it also reduces the opportunity to take advantage of less expensive commodities. Although suspension technologies are improving, it is still difficult to incorporate many dry ingredients into liquid feeds. Therefore, most protein sources used in liquid feeds contain a high proportion of non-protein nitrogen and highly soluble natural proteins. As with other self-feeding systems, liquid supplement intake is more variable than that of hand-fed supplements.

When data from several studies of group-fed animals were compiled, the percentage of animals that did not eat any liquid feed ranged from 17% to 49% (Bowman et al., 1997). In a New Mexico State University trial conducted over two years, 17% of the cows did not consume any liquid supplement. Supplement in-take ranged from 0 to 5.4 lb per day (Pulsipher, 2000), which is consistent with the range reported in other studies. This indicates that, while the average performance of a herd may be similar among liquid feeds and dry feeds, the uniformity of individual animal performance response may be lower with liquid supplements. Very few research trials have attempted to directly address this question.

Hardened molasses blocks

Hardened molasses blocks (often referred to as "tubs" or "soft-pours"; Figure 5) share some characteristics with both pressed blocks and liquid feeds. This type of supplement is generally made from a molasses base, like a liquid feed, but is cooked or chemically hardened to create a block-type feed. These supplements can incorporate a higher percentage of dry ingredients than liquid feeds. Due to the amount of molasses in the formulation, they typically have lower amounts of dry feedstuffs than pressed blocks.

Figure 5. Soft-pours are commonly used as a self-fed method to deliver supplements.

Hardened molasses blocks are self-fed supplements. As animals lick the block, saliva softens the surface and allows the animals to scrape off the softened portion. Intake is dependent on the rate of softening. Harder blocks are designed for slower consumption (lower intake) and do not soften as easily. However, increasing block hardness to reduce intake of molasses blocks also increases intake variability (Kendall et al., 1983). When compared with hand-fed dry supplements or liquid feeds under a variety of conditions, molasses blocks had the highest variation in individual animal intake (Table 7; Bowman et al., 1997).

Molasses blocks are more environmentally resistant than pressed blocks, and the delivery frequency can therefore be decreased. However, since livestock must be checked periodically, the total labor cost associated with feeding hardened molasses blocks may not be significantly less than feeding dry supplements once per week.

Something to consider when utilizing protein tubs specifically are the empty containers. Feed companies no longer provide rebates on the empty tubs. This can lead to a waste issue that would require additional product handling. There are products with biodegradable containers, but this option can be more expensive.

Intake Variability and Proportion

Item	Molasses blocks[a]	Dry supplements[b]	Liquid supplements[a]
Intake range (lb)	0-6.0	0-3.5	0-5.8
Non-eaters %[c]	14.3	5.0	23.5

Table 7. Intake Variability and Proportion of Non-eaters of Hardened Molasses Blocks, Hand-fed Dry Supplements, and Self-fed Liquid Supplements. a. Self-fed. b. Hand-fed. c. Estimated intake range includes the middle 97% of animals consuming supplement (some extremes may occur).

Ingredient Technology

As referenced earlier, non-protein nitrogen (NPN) sources like urea or liquid fermentation byproducts can provide an excellent opportunity to reduce overall feed costs. These are most commonly found in liquid feed supplements, but may also be included as an ingredient in pressed blocks and high-protein cubes. It is important to remember that the utilization of NPN is limited with low-quality diets (NAESM, 2016). Non-protein nitrogen occurs naturally in many feedstuffs (an example is lush pasture such as wheat), and is well utilized in the rumen if adequate energy is present in the diet. Excessive NPN in the supplement, coupled with slow energy release from dormant forage, can result in inefficient NPN use, potentially reducing animal performance. To address the potential issue of forage digestibility, feed manufacturers now offer slow-release NPN additives to better match the rumen environment of low-energy diets.

Manufacturers have also improved technology to in-corporate fat into their products. Fat offers 2.25 times the energy of carbohydrates, but can present challenges when added to feedstuffs. Product shelf life, stability, and the pelleting process can be negatively impacted in added-fat supplement formulas. Through research and development, there are now cubes, pressed blocks, and liquid feed formulations that contain greater than 3% crude fat. Increased fat in the diet can be beneficial to help young heifers continue to grow through the winter, or add condition to thinner cows. Price, feeding rates, and palatability should be considered when selecting an added-fat product. Palatability and forage digestibility in the rumen may be negatively impacted if dietary fat exceeds a certain level. When heifers were fed a ration containing either a 3% or 6% level of soybean oil, those on the higher-fat diet had reduced feed efficiency (Funston, 2004). Today's added-fat products generally contain 4–5% fat, which falls within the range that will not affect forage digestibility, but will add overall beneficial energy to the diet.

Considerations

Supplemental feeds are designed to provide a given level of nutrients to each animal in the herd. Much of the variation in response to supplementation programs has been attributed to variation in supplement intake by individual animals (Huston, 2000). Researchers at Montana State University compiled intake data from both sheep and cattle under a wide variety of environments and supplement formulations, and found that 5% of hand-fed animals failed to consume any supplement, while 19% of self-fed animals did not consume any supplement (Bowman et al., 1997). The total variation in supplement intake was twice as high for self-feeding compared to hand-feeding. This may result in substantial variation in response to a supplemental feeding pro-gram since many animals fail to consume the targeted amount, while others consume in excess.

Intake variation also occurs with hand-fed supplements, but the variation is generally less dramatic. Depending on the acceptance of the supplement and the effectiveness of the intake limiter, more variation in animal performance may occur with self-fed supplements. Supplement intake variation depends on factors unique to each operation. However, producers should be aware of the potential for greater variability in self-fed supplement intake, and therefore more variability in the performance responses to these supplements. If total available forage is not adequate to meet daily intake requirements, cattle will over-consume self-feeding protein and energy supplements. This can not only cause an in-crease in daily costs but can also have detrimental effects on rumen health and animal performance.

Additionally, trough space greatly influences the variation in intake and the number animals that fail to eat supplement (Bowman et al., 1997). Trough space of 2.5 ft per head appears to be ideal for range cows to minimize intake variation and allow more cattle to consume the supplement (Wagnon, 1965). For sheep, ideal trough space is approximately 10 in. per head (Arnold et al., 1974).

General Conclusions

A variety of supplement types are available for range livestock producers. The most efficient and effective supplement delivery system depends on individual circumstances and may vary from ranch to ranch. For energy and mineral supplementation, self-fed delivery methods are probably more labor efficient since these supplements should be consumed on a daily or every other day basis. With energy supplements, large quantities are usually supplied, and even with self-fed supplements the supply may need to be replenished frequently. When feeding protein supplements, less frequent feeding (up to once per week) is as effective as daily delivery, and labor costs may be reduced to levels similar to those of self-fed supplements with less intake variation.

Different supplement delivery systems have different advantages and disadvantages. The overall benefit of using a particular system depends on the individual situation. Supplement delivery systems can be ranked (1 = best) based on several different criteria.

Flexibility of least-cost formulation:

1. Cubes or meals
2. Pressed blocks
3. Hardened molasses blocks
4. Liquid feeds

Labor and delivery costs:

1. Liquid feeds, dealer filling feeders
2. Hardened molasses blocks
3. Small package meals (e.g., mineral)
4. Pressed blocks
5. Hand-fed cubes

Flexibility of feeding location:

1. Cubes
2. Small package meals
3. Blocks (any type)
4. Liquids
5. Large package meals (protein or energy)

Summary

Supplemental feeding of protein and/or energy to grazing beef cattle in the western United States is practiced commonly and accounts for a significant economic input into beef production enterprises. It is important that money is not spent unnecessarily on nutrients that are not limiting animal performance.

More specifically, it is important that when protein is deficient, producers do not spend money feeding cattle supplemental energy that can be supplied by the forage in the pasture, or spend money on high concentrations of protein in a supplement when energy is deficient.

When forages are low in protein, providing supple-mental protein can increase both forage intake and digestion, ultimately improving both the protein and energy status of the cow. When forage supply is low and energy limits the performance of the cow herd, providing supplemental energy in the form of highly digestible fiber should increase the cow's energy intake while minimizing the potential for substitution.

However, if the forage supply is so low that it would be desirable to reduce the amount of forage harvested daily by the cow herd, then the herd should be fed high levels of energy; the source of energy (starch vs. fiber) would be of less importance.

The primary goal of any supplementation program is to deliver targeted amounts of specific nutrients in a uniform and consistent manner to generate predictable results. Variability in supplement intake is a major cause of variable performance responses to a supplemental feeding program. Some systems may deliver nutrients more precisely, but the costs and benefits of each system should be evaluated.

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Range Evaluations and Stocking Rates

Introduction

Evaluating rangeland conditions and potential use is critical to maintaining or improving natural resources. Monitoring is the first step in developing a plan and is defined as the orderly collection, analysis, and interpretation of resource data, over time, to evaluate progress toward meeting management objectives. There is a variety of methods used to collect this information, as well as many potential parameters that can be measured. The combination of these can make the process of starting monitoring seem untenable. However, there are key components of any rangeland assessment, that when looked at as a whole, can provide invaluable information. The second step is translating the monitoring information into a useful format; a carrying capacity or stocking rate estimate being the primary goal. Nevertheless, grazing strategies such as timing, intensity, duration, and density will contribute to how the stocking rate is used. All other inferences from the monitoring information are generally used to assess whether the stocking rates align with the management objective or if adjustments need to be made. This is the third and final step in developing a management plan.

Where to Monitor

Selecting areas representative of the landscape are key for site selection. Understandably, rangeland pastures vary greatly across the landscape and certain factors may contribute to under or over representation of vegetation present. Thus, there are some general factors to consider when selecting an assessment site. Because animals tend to congregate around infrastructure and look for easy travel pathways, it is suggested to select areas a quarter to one mile from water sources, fences, roadways, and other man-made structures. Additionally, it is recommended to select sites with slopes less than 15%, soils of satisfactory condition, and areas of greater than 5 acres.

When to Monitor

Timing of monitoring can have profound impacts on the collected information. Estimating forage availability is best done at the end of the growing season. Depending on the vegetation type (cool- or warm-season grasses) the timing will be different. Environmental conditions may also influence sample collection timing. For instance, droughty conditions may require more frequent assessments in order to make short-term management decisions. No matter the timing, measurements should occur annually, for repeatability, and to develop trends over time. Trends can then be used to establish a baseline for long-term management planning.

What to Monitor

Ocular estimation

Producers often use this method and take mental notes for management decisions. Although useful, they are difficult to quantify. Thus, the same observer should make the assessment and use a categorical system. For instance, when observing general conditions, normality categories can be used (i.e., well below, below, normal, above, and well above normal) or when observing available forage, percentages can be used (i.e., 0-20, 21-40, 41-60, etc…). Ocular estimates are subjective but using a categorical system helps to minimize this.

Photo Points

Photographs give a point in time visual record of range conditions and support quantitative measurements. Upon site selection, a marker should be used to be able to identify location and repeat the photograph. Two photos should be taken per site. A landscape-level photo gives a panoramic estimate of the area condition. This photo should include some permanent identifiable feature of the landscape (i.e., hill, drainage, or rock outcrop). A sign that can easily be seen in the photo should be used with key information such as pasture name, date, photo point number, and other pertinent information. The second photo should be a ground-level photo near the marker point that represents ground-level characteristics. A scale ruler should be used to quantitatively determine the size aspects of the photo. A two-meter carpenter ruler bent in half at a right angle is recommended. When photos are taken over consecutive years, the original photo should be in hand for duplication purposes.

Transects

Several types of transect methods exist to assess vegetation conditions. A transect is the process of extending a line (usual a tape) between two points and taking measurements at designated intervals along the line. One of the most commonly used methods is *line-point intercept*. As the name depicts, a rod or pin is dropped at points along the line and an assessment is made at its point of contact. However, when multiple transects are being assessed, this method becomes very time consuming. A more rapid method is that of *step-point*. A mark is placed on the tip of the boot and with every stride an assessment is made at the tip of the boot. This method reduces the time commitment required but decreases the accuracy for repeated measurements. Line-point greatly increases the accuracy of measurements over time.

Several types of measurements can be made with these types of transects. In general, *cover* is the process of assessing the vertical projection of plant parts from the ground as a percent. Three categories of assessment exist. Aerial or *canopy cover* is the upper area of plant foliage that shades or covers the ground. A second measurement is that of *foliar cover*, which entails detailing all leaves of plants relative to the ground they cover. It is slightly different than canopy cover because it measures all layers of foliage rather than just the overall shading of the ground. *Basal cover* is the measurement of the plant near the junction of the ground and plant (stem). Ground cover measures soil attributes (bare ground, rock, soil crust, plant litter, and presence of a plant) and is good for assessing erosion potential.

Other assessments can also be made along the transect. *Species composition* is the process of counting and identifying each plant, which gives an estimate of the proportion of a certain species within the plant community. Additionally, plants can be counted as individuals or classified into groups of species (i.e., annual grass, bunch grass, annual forb, etc…) depending on management

objectives. However, sensitive or endangered species should be counted as individuals.

Although species composition is good for counting the most abundant plants in the community, plants of low abundance may be missed. Thus, a *belt transect* is a useful tool to capture those infrequent species. Belt transect is the process of counting targeted plants within a designated width on either side of a transect (generally 3 feet on either side).

Grids and frames are a valuable tool to measure plant density and/or frequency. These can be applied at designated intervals along a transect or randomly placed throughout the monitoring area. *Density* assesses the number of individual plants in a given area, whereas *frequency* is the probability of finding a particular species within the given area. Both methods are expressed as percentages and are useful tools to determine the vegetation structure of rangelands.

Finally, *stubble height* can be taken at designated intervals along the transect concurrently with speciation. This process involves extending the leaves of the plant upward, along the stem, and measuring the average length of the longest leaves. This is not intended to be the overall height of the plant but an estimate of remaining forage when not excluded from grazing.

Forage Quantities

The amount of forage available for livestock is determined by collecting vegetation samples from a designated area, drying, weighing, and converting those weights to pounds of forage per acre. Total available forage can be calculated by the following equation: *available forage in lbs per acre* × pasture size in acres

Available forage data can be assessed in two ways, standing crop or residual forage and annual forage production. *Standing crop* is plant material collected with possible defoliation from animals. This type of assessment should only be used to estimate current forage availability and make short-term or immediate management changes. Annual forage production is plant material collected from grazing exclusion cages and used to assess forage production for the year. Without grazing, plants can go through their full growth cycle more accurately representing total production. Once estimates are made, cages should be moved. Subsequent years of accumulating vegetation within the cage alters the natural growth cycle of plants, leading to over- or under-estimations. When annual forage assessments are taken over 5-10 years, trends can be established to make long-term management plans, whereas 3-5 years of data can be used to make short-term management plans. Standing crop assessments can be taken any time during the year, while annual forage should only be taken at the end of the growing season. Both standing crop and annual production should be collected and weighed in the same manner. Also, three or more areas should be clipped for both types of production in order to account for variability within the landscape.

Utilization

The percentage of forage removed by grazing animals is referred to as utilization. When standing crop and annual forage production data is available the two can be used to deduce an approximate percent utilization level. The following is an equation to estimate percent utilization: *(annual forage production – residual forage) ÷ annual forage production*

Utilization is only an approximation of forage use and an estimate of grazing intensity. Light to conservative grazing (0 to 40 percent) in New Mexico optimizes vegetation and livestock productivity, whereas moderate to heavy grazing (over 40 percent) can lead to rangeland deterioration if grazing intensity persists over the short-term.

Estimating Stocking Rates

Landscape Adjustments

Several parameters limit livestock utilization of forages across the landscape. It is important to consider these elements when estimating stocking rates. For instance, as distance from water or slope increases, vegetation use decreases. The exception to this is goats and sheep, which do not require water daily and can forage more readily on rugged terrain. Cattle on the other hand tend to graze flatter terrain and stay closer to water. Thus, tables 1 and 2 give recommended grazing adjustment for cattle only. For sheep and goats, distances less than 2 miles from water and slopes less than 45 percent are considered to be used at 100 percent. There can be significant overlap of slope and distance from water in adjustment calculations, thus these should be calculated separately and the greatest reduction used. The following are equations used after preliminary stocking rate has been estimated:

WATER: (% area <1 mile × 1)+(% area 1–2 miles × 0.5)+ (% area 2+ miles × 0) × AUE

SLOPE: (% area 0–10% × 1)+(% area 11–30% × 0.6)+ (% area 31–60% × 0.3)+(% area >60% × 0)] × AUE

Grazing reduction with slope for cattle

Percent Slope	Percent Reduction in Grazing Capacity
0-10	None
11-30	30
31-60	60
Over 61	100 (considered ungrazable)

Table 1. Grazing reduction with slope for cattle
Source: Holechek (1988)

Cattle grazing reduction with distance from water

Miles	Percent Reduction in Grazing Capacity
0-1	None
1-2	50
Over 2	100 (considered ungrazable)

Table 2. Cattle grazing reduction with distance from water
Source: Holechek (1988)

Forage Demand

Animals consume on average 2 percent of their body weight per day on a dry matter basis. Intake of ruminants may be higher or lower depending on forage quality and stage of production (NASEM, 2016). Horses and donkeys can consume up to 50 percent more forage per day due to variations in their digestive system. Forage demand is used to standardize the number of animals a pasture can support through animal unit equivalents (AUE). One mature cow of 1000 pounds, with or without a calf up to six months of age, is considered one AUE. There is considerable variation between agencies in the calculating AUE across different animals. For instance, North Dakota State University bases AUE on metabolic weight rather than dry matter intake (Manske, 1998). However, basing AUE off dry matter intake can give a general estimate and suffice in calculating stocking rates. Rangeland animals and their unit equivalents on a dry matter basis can be found in Table 3.

Animal	Animal Weight (lbs)	Daily Dry-Matter Intake (lbs)	Animal Unit Equivalents (AUE)
Cattle (Mature)	1000	20.0	1.00
Cattle (Yearling)	750	15.0	0.75
Sheep	150	3.0	0.15
Goats	100	2.0	0.10
Horse	1200	36.0	1.80
Donkey	700	21.0	1.05
Bison	1800	36.0	1.80
Elk	700	14.0	0.70
Moose	1200	24.0	1.20
Bighorn Sheep	180	3.6	0.18
Mule Deer	150	3.0	0.15
White-tailed Deer	100	2.0	0.10
Pronghorn Antelope	120	2.4	0.12
Caribou	400	8.0	0.40

Table 3. Forage demand of various rangeland animals
Source: Holechek (1988)

Calculations

Once total available forage quantities, desired utilization, and animal forage demand is known, stocking rate can be calculated. Carrying capacity is often synonymous with stocking rate but is different as it considers all grazing animals (i.e., wildlife). Stocking rate is specific to calculating the number of livestock that can be used for grazing. Animal unit equivalents can be adjusted for grazing duration and are standardized as animal unit day (AUD; one day only), animal unit month (AUM; 30 days), and animal unit year (AUY; 365 days). However, if a pasture has a specified grazing duration (i.e., leases or allotments), AUE can be adjusted by multiplying animal forage demand by the specified time period, expressed as animal units per designated days. The following is a generalized equation used to estimate stocking rate with examples: (*total available forage × percent utilization) ÷ (animal forage demand) = AUE*

EXAMPLE 1: A 20,000 acre cattle ranch produces a yearly average of 550 lbs of forage per acre. A utilization of 35% is desired. The ranch uses a year-long continuous grazing system (365 days).

total available forage = 20,000 acres × 550 lbs = 11,000,000 lbs
animal forage demand = 20 lbs per day × 356 days = 7300 lbs
AUY = (11,000,000 lbs × 0.35) ÷ 7300 lbs = ***527 AUY***

EXAMPLE 2: Using the same ranch from example 1, 60% of the acreage has water available to cattle within 1 mile, 30% between 1 and 2 miles, and 10% over 2 miles.

(0.60 × 1)+(0.30 × 0.5)+(0.10 × 0) × 527 AUY = ***395 AUY***

EXAMPLE 3: Using the same ranch from example 1, 40% of the acreage has slopes less than 10%, 20% with slopes between 11 to 30%, 30% with slopes between 31 to 60%, and 10% with slopes greater than 60%.

(0.40 × 1)+(0.20 × 0.60)+(0.30 × 0.30)+(0.10 × 0)] × 527 AUY = ***321 AUY***

Works Cited

Holechek, J.L., 1988. An approach for setting the stocking rate.

Manske, L.L., 1998. Animal unit equivalent for beef cattle based on metabolic weight.

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